Global Energy Needs and Sustainability Issues

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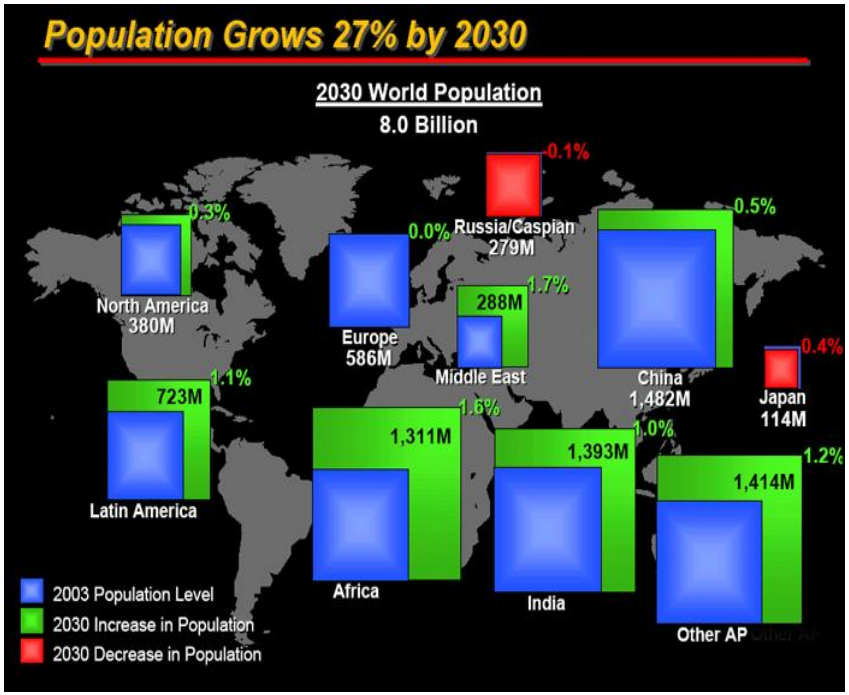
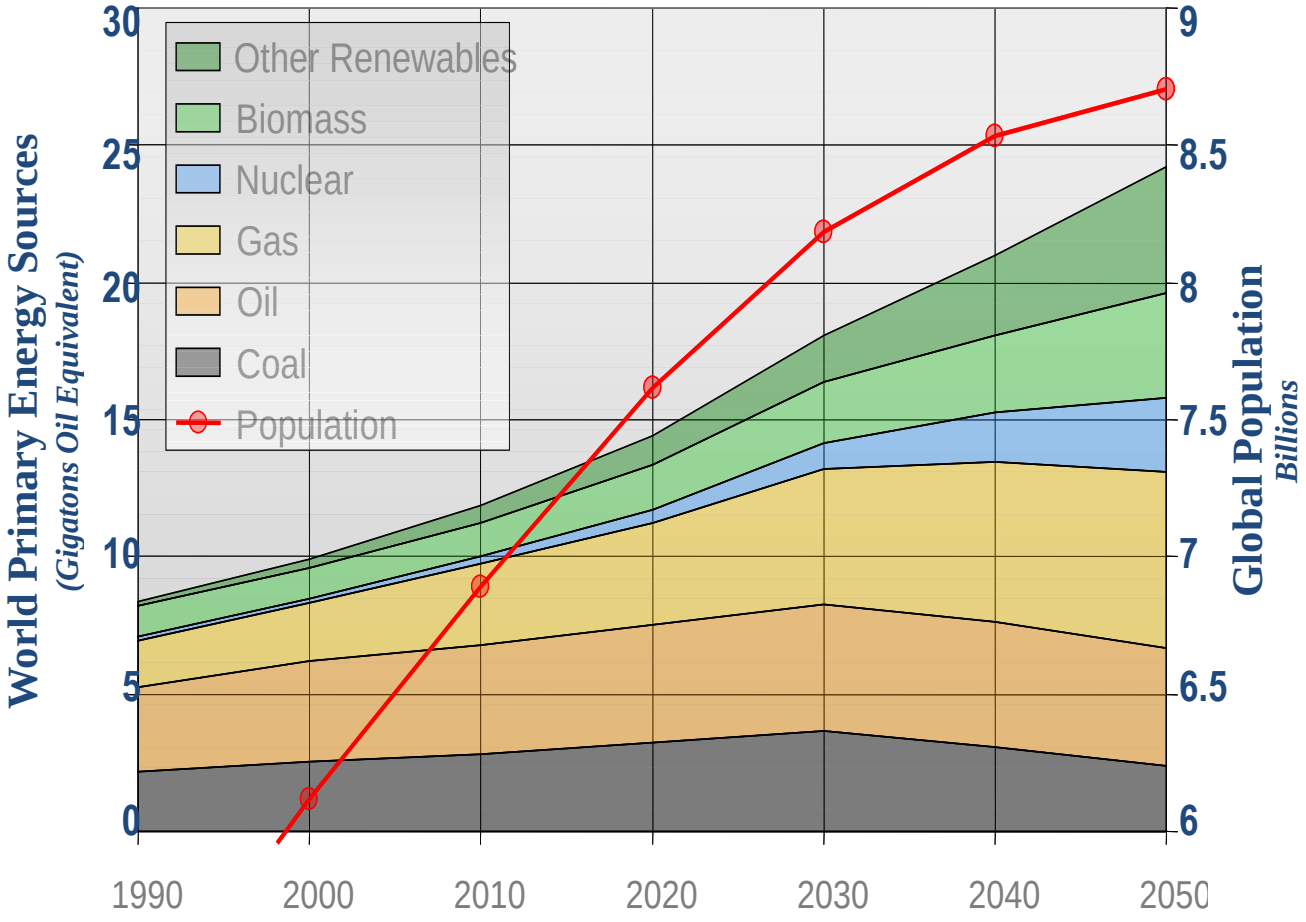
Energy: Our Grand Challenge

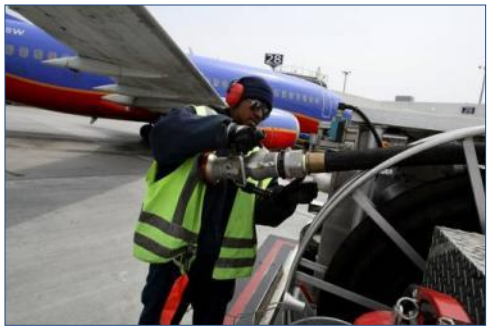
- Global population marches on
  - Over 8 billion by 2030; 9 billion by 2050
  - Globalization of economies continues
  - 3 to 5 fold increase in economic activity
- Access to stable, affordable energy is key to peace and prosperity
  - 40% increase in demand by 2030 (IEA estimate)
  - 2-3 fold increase in demand by 2050 (WBCSD estimate)
- Greatest energy consumption growth in non-OECD countries
  - China, India and Middle East account for over 90% of the increase



Sources: United Nations Population Division
And United States Energy Information Agency

Energy Use Today

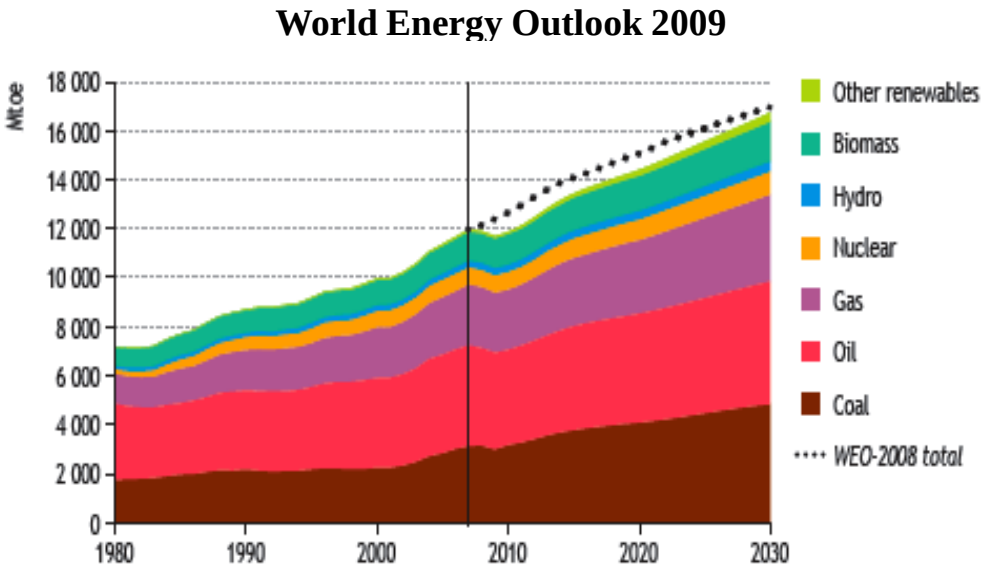




Source IEA : Energy to 2050 - Scenarios for a Sustainable Future

Energy Markets at a Crossroads

- As energy needs rise, oil and gas prices are more volatile, and pace of global warming increases, nations are looking to new sources of clean energy
  - Geothermal, hydroelectric and nuclear are the only carbon-neutral base load electricity sources
- Sustainability challenges exist for all energy generation technologies
- Greatest opportunity is in expanding access to clean energy

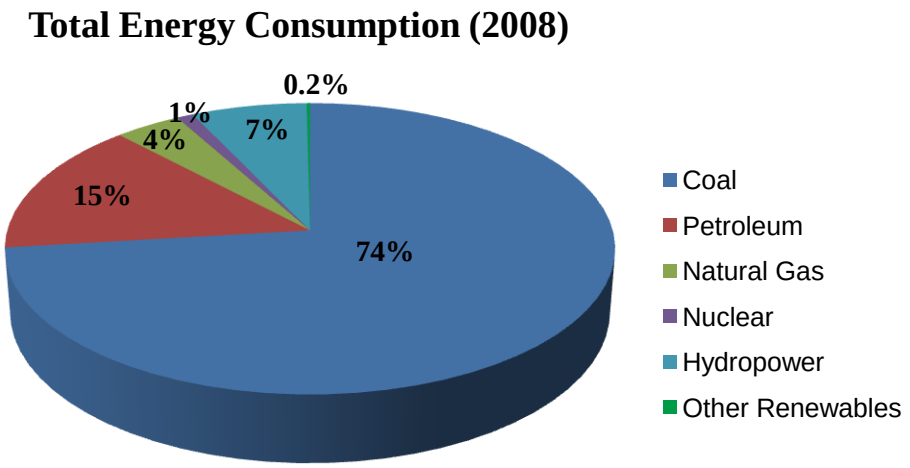


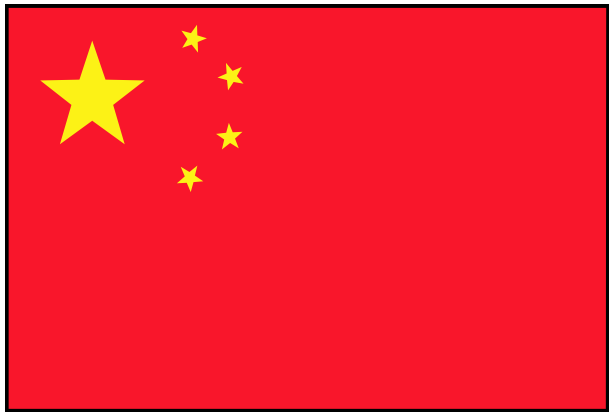
U.S. and other countries will have no choice but to add more renewable energy, more nuclear energy, more energy efficiency & conservation and more oil and gas from unconventional sources.

Remember – Energy Density & Infrastructure

China's pattern of demand and supply growth mirrors U.S. experience

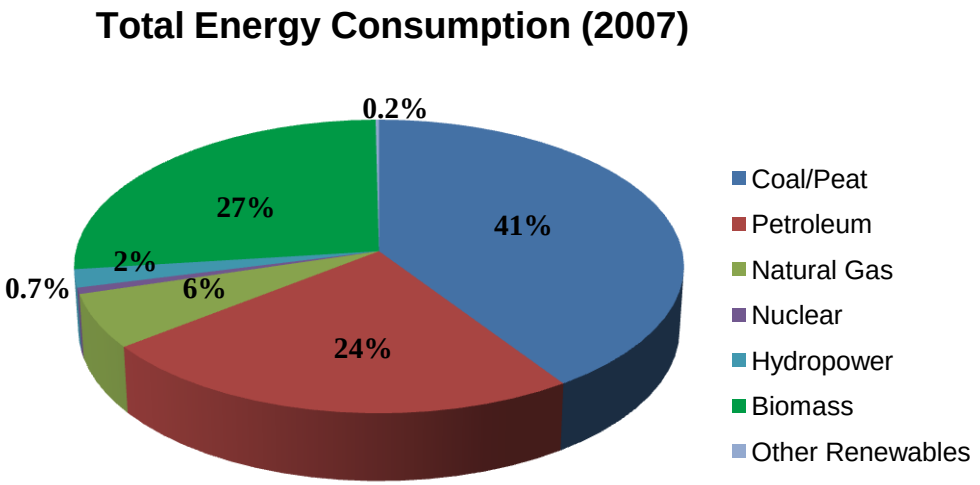
- Most populous country in the world (over 1.3 Billion)
- World's largest consumer of energy
- Relies on coal for electricity and heat
- Largest consumer of coal in the world – many coal reserves have yet to be developed
- Private automobile ownership increasing at over 15% per year
- Pursuing ambitious plans to grow renewable and nuclear energy



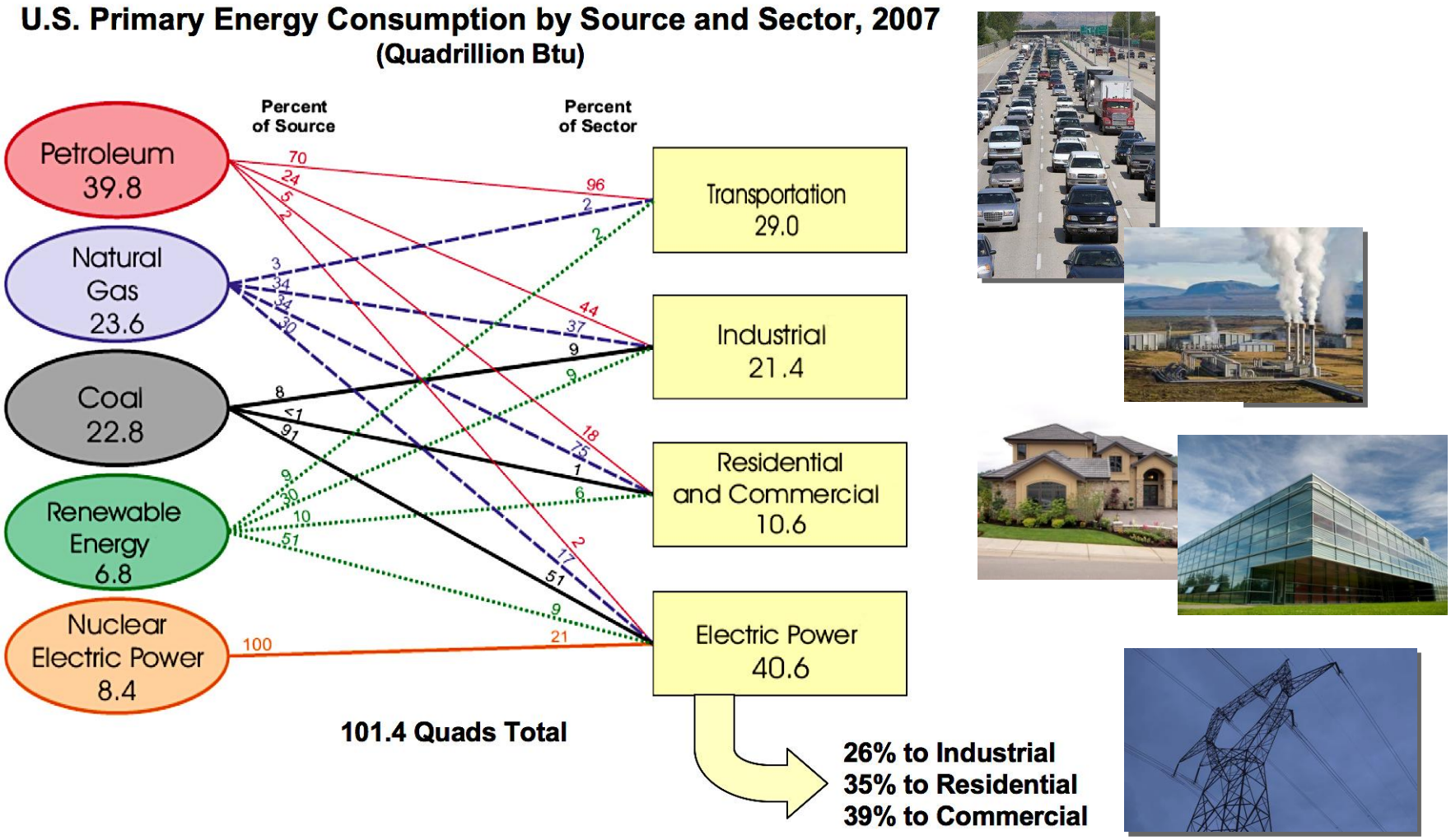


India's energy challenge is enormous

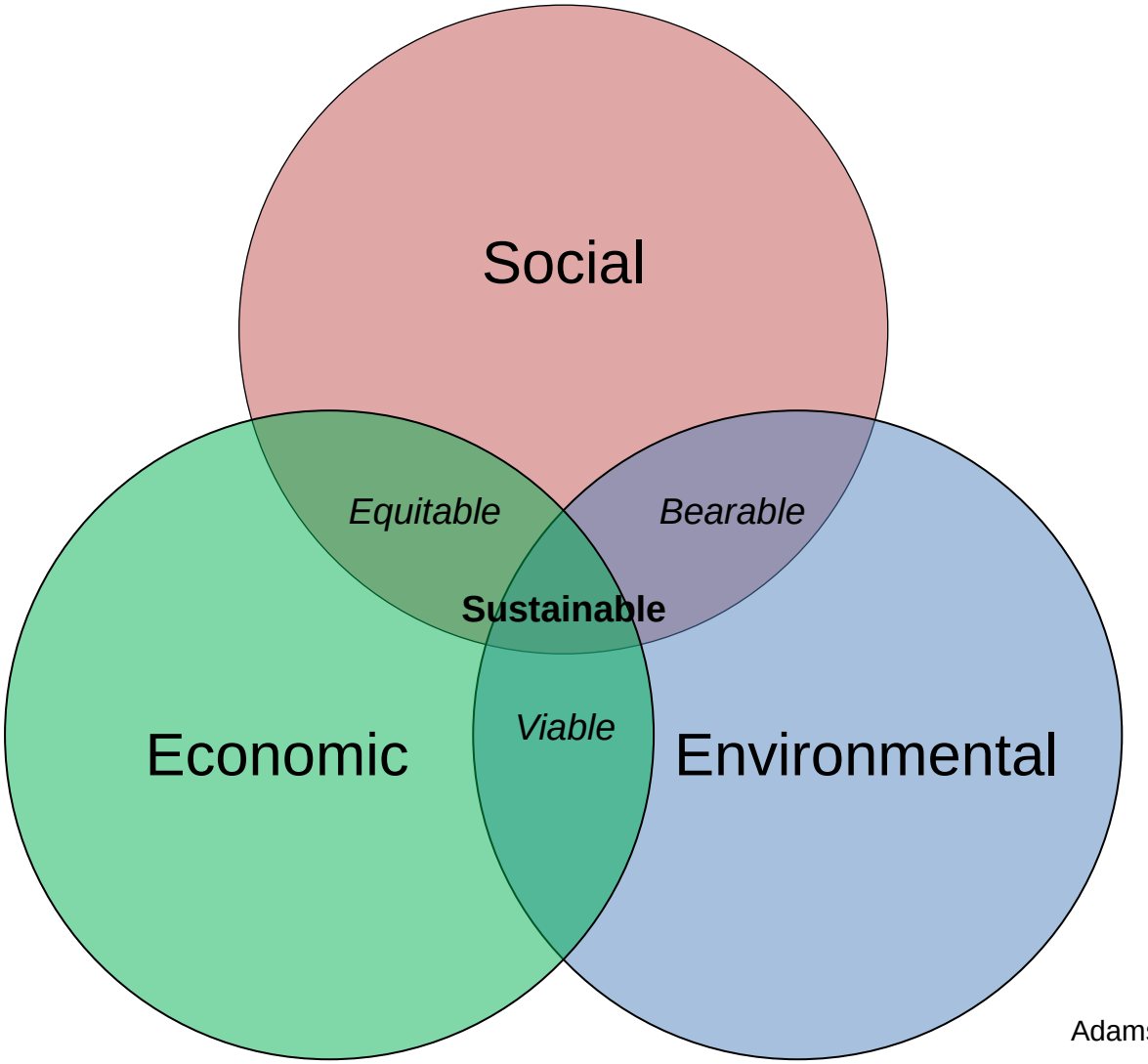
- Second most populous nation in the world (1.2 Billion)
- World's 5th biggest energy consumer; will surpass Japan and Russia to take 3rd place by 2030
- World's 4th largest oil consumer
- Coal accounts for almost half of country's energy consumption
- Modest domestic energy resources
- 80% of country has electricity but reliability is an issue
- 400 million people do not have access to electricity



Energy — Beyond Electricity

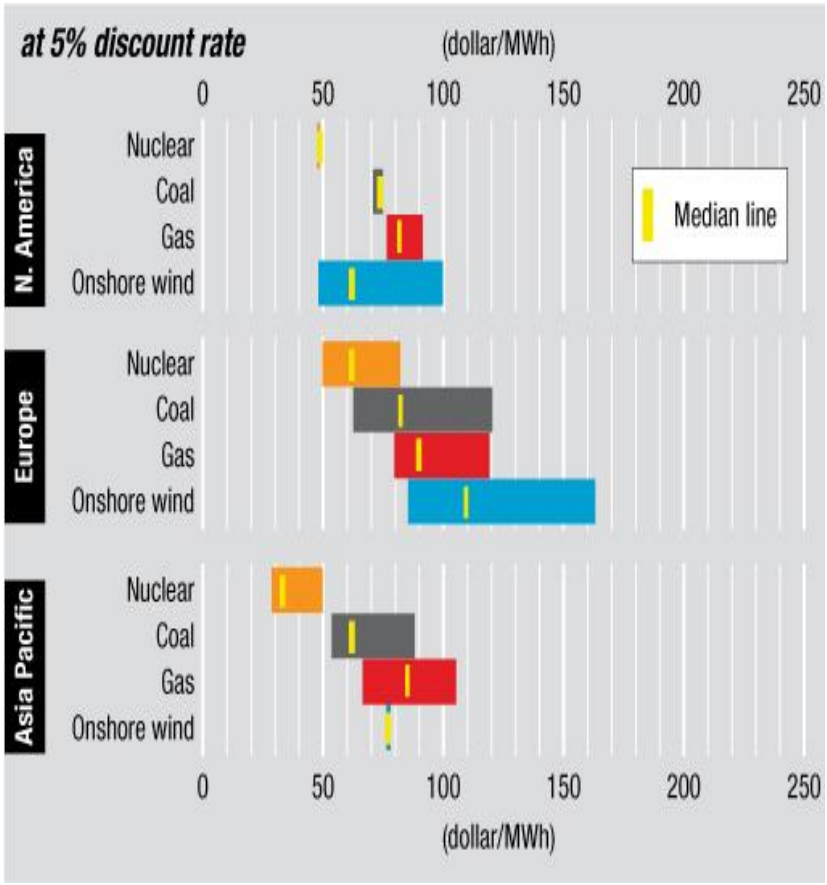


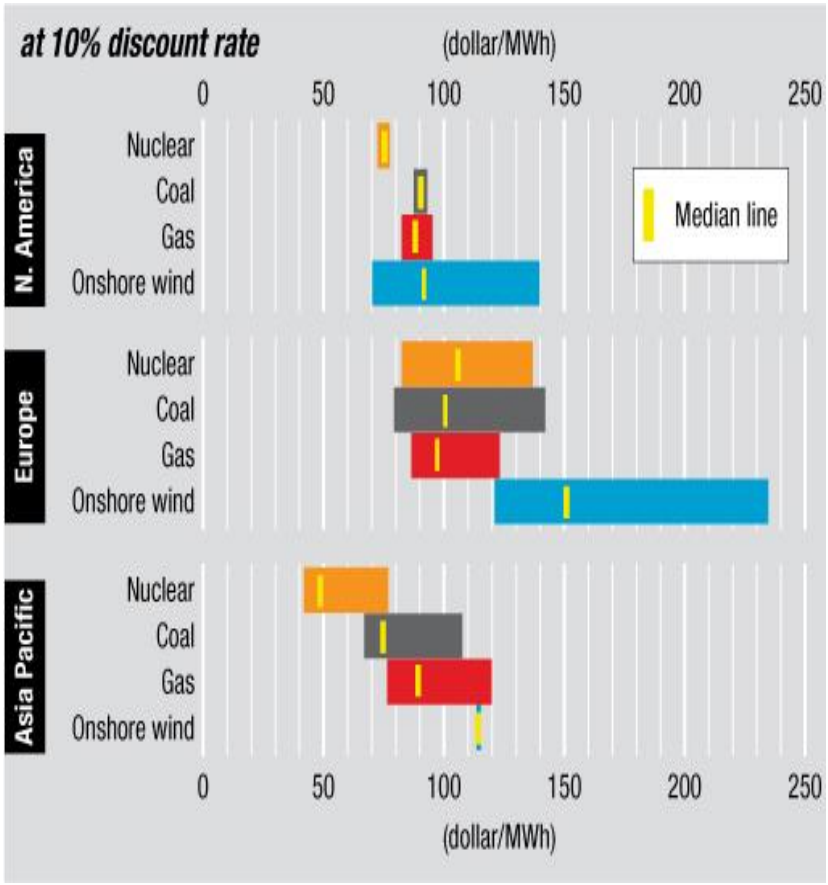
Sustainability Dimensions



Adams, E. M. (2006)

Levelized Costs of Electricity: A Global Look Forward

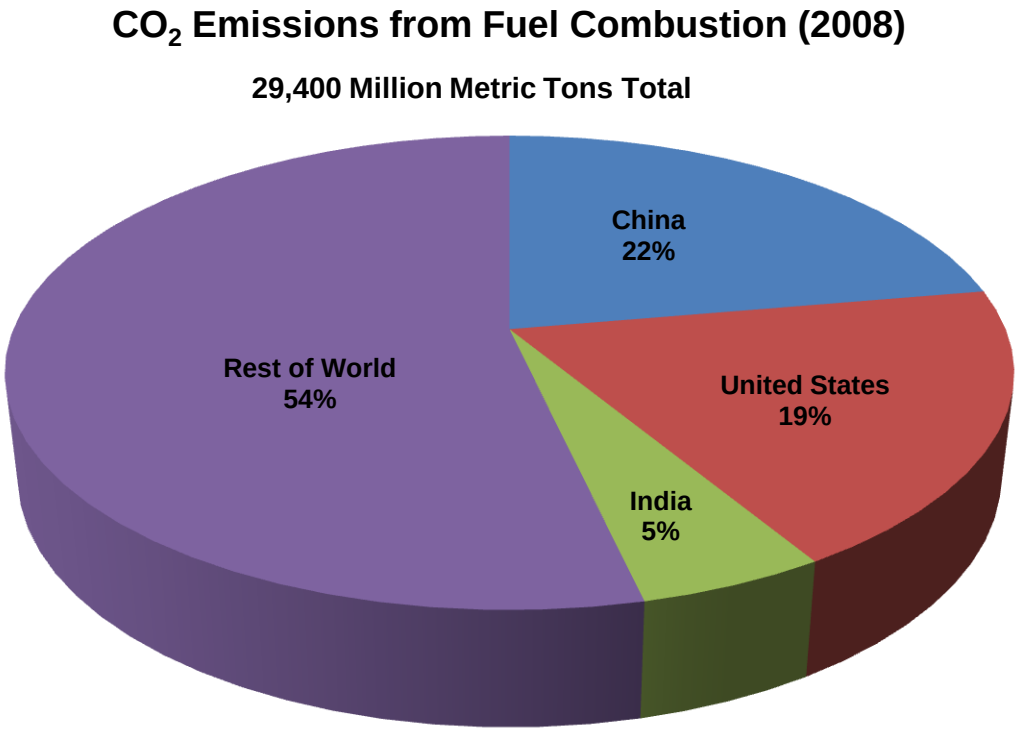




Source: Projected Costs of Generating Electricity – 2010 Edition, International Energy Agency

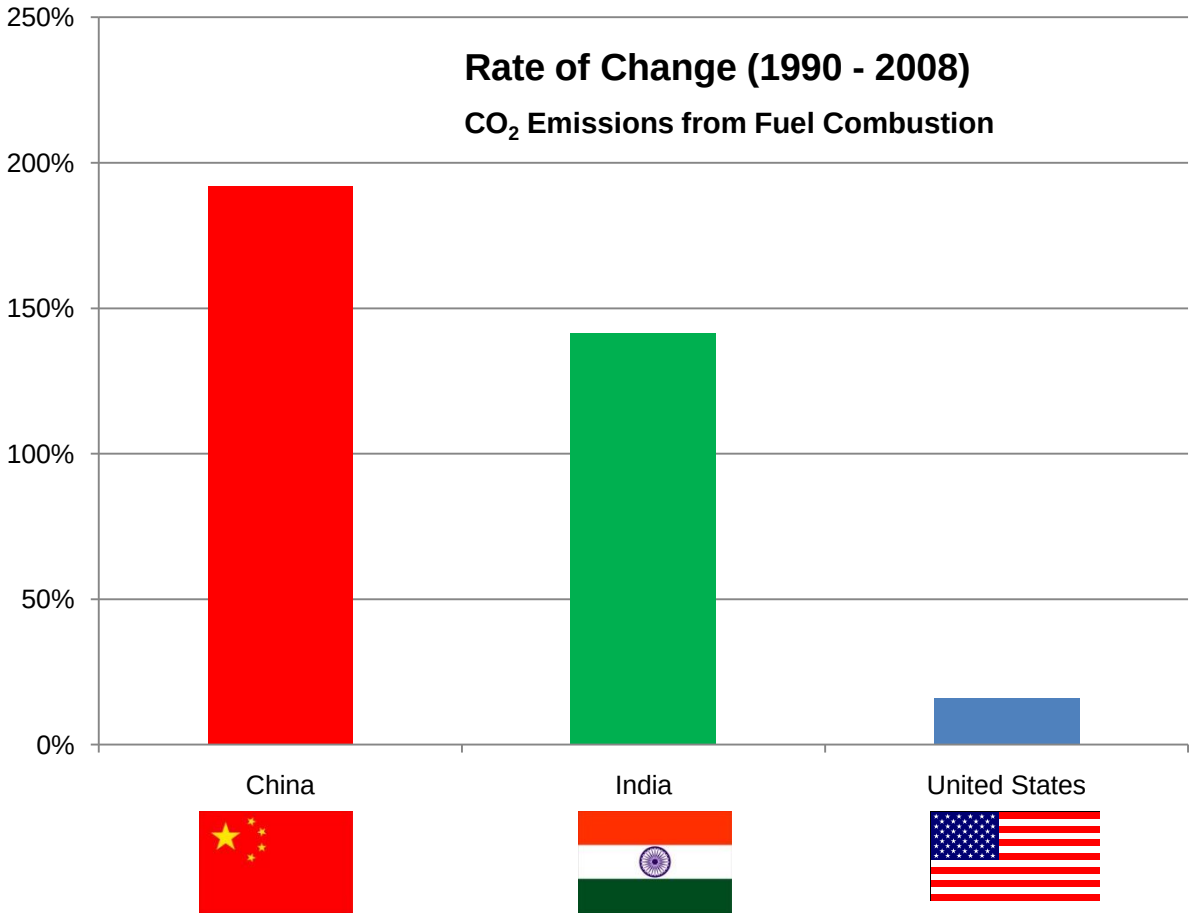
The United States is Not the Largest GHG Emitter

This title now belongs to China



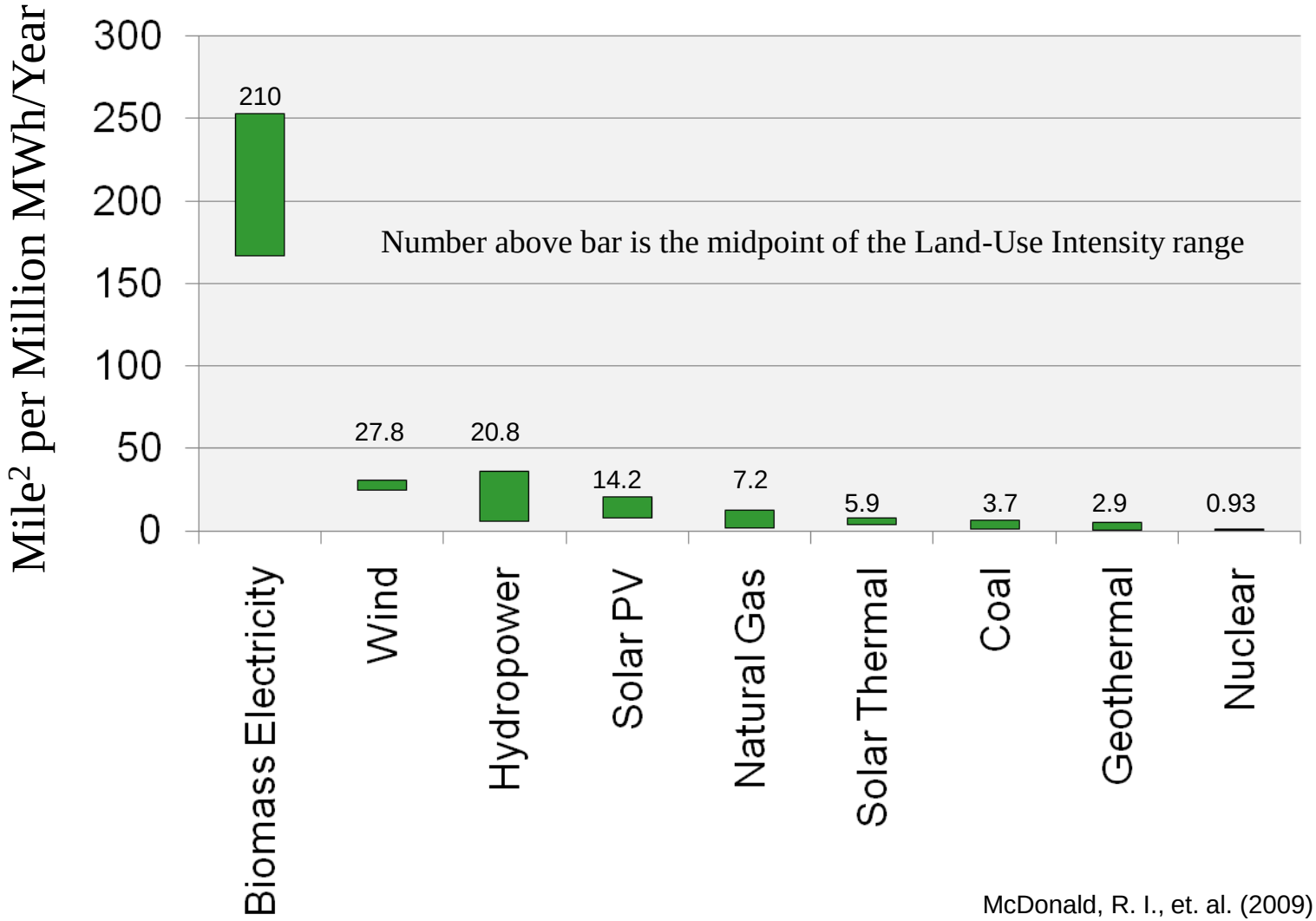
International Energy Agency

Emissions are Increasing Rapidly in the Developing World



International Energy Agency

Land-Use Intensity Varies Widely by Technology



McDonald, R. I., et. al. (2009)

A Balanced Energy Portfolio is Needed for Our Future

- End user efficiency and conservation are important, but cannot fully satisfy growing demand
- Renewables and distributed energy sources are needed but don't all scale to meet the demand of large population centers and industrial activities
- Carbon capture and sequestration from coal has significant uncertainties
- Large-scale technology development and deployment takes time
- Energy generation, transmission, and distribution infrastructures take time to develop, and substantial resources to modify and deploy

There are NO Easy Solutions

A Balanced Energy Portfolio is Needed for Our Future

- Satisfying the world energy demand is a global challenge requiring a diversified and balanced portfolio
- Local, State, Regional, National, and International portfolios of demand reduction (conservation), energy efficiency, renewables, fossil and nuclear are needed

Energy demand, resource availability, costs, risks, and environmental impacts determine portfolio balance

A Balanced Energy Portfolio is Key to Our Future

All forms of energy generation have costs, risks, and impacts